REMARKS

Applicants are amending their specification in order to correct typographical errors. It is respectfully submitted that these amendments to the specification do not add new matter to the application.

Applicants are amending their claims in order to further clarify the definition of various aspects of the present invention. Specifically, Applicants are amending claim 1 to recite that the cobalt film is deposited on a bare silicon surface of the main surface of the silicon substrate. Applicants are amending step (a) of claim 5 to recite a "first-stage" heat treatment; and are amending step (c) of claim 5 to recite removal of an unreacted portion of the cobalt film after the second-stage heat treatment, and a third-stage heat treatment for forming a main component of a cobalt disilicide layer by converting the main component of the silicide layer. Applicants are amending claims 8 and 17 to recite that the cobalt film is deposited on a bare silicon surface; and are further amending claim 8 to recite that the depositing of the cobalt film is conducted at a temperature lower than a temperature at which a reaction layer of silicon and cobalt is formed on the interface between the silicon substrate and the cobalt film. In addition, claim 18 has been amended to delete therefrom the preferred and more preferred deposition temperatures of the cobalt film; in connection therewith, attention is respectfully directed to new claims 20 and 21, dependent respectively on claims 18 and 20, and respectively reciting the preferred and more preferred deposition temperatures of the cobalt film.

In connection with amendments to previously considered claims, note original claim 1, and also note, for example, the second full paragraph on page 13, and first paragraph on page 15, of Applicants' Substitute Specification.

In addition to claims 20 and 21, Applicants are adding new claims 22-26 to the application. Claims 22 and 23, each dependent on claim 8, respectively defines materials of which the oxidation barrier film is made; and recites a temperature of the surface of the silicon wafer during deposition of the oxidation barrier film, consistent with descriptions on pages 16 and 17 of Applicants' Substitute Specification. Claim 24, dependent on claim 25, recites that the second-stage and third-stage heat treatments are carried out in non-oxidizing atmospheres, consistent with descriptions on pages 19 and 20 of Applicants' Substitute Specification. Claims 25 and 26, each dependent on claim 1, respectively recites that the first step (of depositing the cobalt film) is performed for 15 seconds or less; and recites that in the first step the silicon substrate is cooled. See, for example, the second paragraph on page 15 of Applicants' Substitute Specification.

The objection to claims 5 and 6 as set forth in Item 3 on page 2 of Office Action mailed January 27, 2005, is noted. This objection is moot in view of amendments to claim 5; and it is respectfully submitted that the required correction has been made.

Applicants respectfully traverse the rejection of claims 5 and 6 under the first paragraph of 35 USC 112, insofar as this rejection is applicable to the claims as presently amended. Thus, claim 5 has been amended to recite removing the unreacted portion of the cobalt film, after the second-stage heat treatment; <u>and</u> a third-stage heat treatment for forming a main component of a cobalt disilicide layer. Thus, as presently amended, the removing of the unreacted portion of the cobalt film is <u>not</u> recited after the recitation of a third-stage heat treatment. In view of claim 5 as presently amended, it is respectfully submitted that this claim is consistent with the Specification, with respect to

removing the unreacted portion of the cobalt film, and with respect to the third-stage heat treatment.

Applicants respectfully submit that all of the claims presented for consideration by the Examiner patentably distinguish over the teachings of the prior art applied by the Examiner in rejecting claims in the Office Action mailed January 27, 2005, that is, the teachings of the U. S. patents to Inoue, No. 6,136,699, to Murphy, et al., No. 6,117,771, and to Agnello, et al., No. 6,440,851, under the provisions of 35 USC 102 and 35 USC 103.

It is respectfully submitted that these references as applied by the Examiner would have neither taught nor would have suggested such a fabrication method of a semiconductor integrated circuit device as in the present claims, including, inter alia, the step of depositing a cobalt film on a bare silicon surface of the main surface of the silicon substrate, and wherein, in this first step of depositing the cobalt film, the film is deposited at a temperature lower than a temperature at which a reaction layer of silicon and cobalt is formed on the interface between the silicon substrate and the cobalt film, with a further step of heat treating the substrate to form a silicide layer on the interface between the silicon substrate and the cobalt film. See claim 1. Note also claims 8 and 17.

Furthermore, it is respectfully submitted that these references would have neither taught nor would have suggested such a fabrication method, including, inter alia, the temperature of deposition of the cobalt film, as discussed previously, and wherein an oxidation barrier film is formed over the main surface of the silicon wafer having the cobalt film deposited thereover (see claim 7), with a silicide layer having dicobalt silicide as a main component being formed in this second sputtering chamber in which the

oxidation barrier film is deposited, the main component of the silicide layer being converted from dicobalt silicide to cobalt monosilicide, thereafter the oxidation barrier film and an unreacted portion of the cobalt film is removed from the main surface of the silicon wafer, and thereafter the main component of the silicide layer is converted from the cobalt monosilicide to cobalt disilicide by a third-stage heat treatment at a temperature higher than the temperature of the second-stage heat treatment. See claim 8; note also claim 17.

Additionally, it is respectfully submitted that these applied references would have neither disclosed nor would have suggested such fabrication method as in the present claims, including the temperature at which the cobalt film is deposited and wherein an oxidation barrier film is deposited over the cobalt film, with a silicide layer having, as a main component, dicobalt silicide being formed over the surface of semiconductor regions constituting source and drain regions of a MISFET formed over the substrate, and wherein the main component of the silicide layer is converted from dicobalt silicide to cobalt monosilicide by heat treatment, thereafter the oxidation barrier film and an unreacted portion of the cobalt film is removed, and thereafter the main component of the silicide layer is converted from cobalt monosilicide to cobalt disilicide by heat treating the silicon substrate at a third temperature higher than the second temperature. See claim 17.

Furthermore, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested the other features of the present invention, as in the remaining claims, having features as discussed previously in connection with claims 1, 8 and 17, and additionally wherein the cobalt film is deposited at a temperature less than 200°C (note claims 2, 9 and 18), more

However, the known practice has problems, in that a junction leakage current resulting from a deterioration in flatness occurs, on the interface between the silicon substrate and the cobalt silicide layer. Note, in particular, pages 3 and 4 of Applicants' Substitute Specification.

Against this background, Applicants provide a process wherein the increase in junction leakage current is reduced. In particular, Applicants have found that by depositing the cobalt at such a low temperature that the silicide is not formed at the interface between the cobalt and silicon of the substrate at the time of deposition, with subsequent heat treatments taking place in order to form the silicide, it is possible to planarize the interface between the substrate and the finally-formed silicide layer composed mainly of cobalt disilicide, thereby preventing an increase in junction leakage current. Moreover, by forming the cobalt film at a low temperature and preventing generation of a reaction layer between silicon and cobalt on the interface between the substrate and the cobalt film <u>during film formation</u>, the subsequent silicide reaction can be allowed to proceed smoothly. See page 16, lines 10-13; and from page 21, line 9 through page 22, line 3, of Applicants' Substitute Specification.

Furthermore, since a well-formed cobalt disilicide layer is formed, by converting the cobalt monosilicide, a cobalt monosilicide layer or dicobalt silicide layer having a high resistance does not remain on the interface between the substrate and the cobalt disilicide layer, improving conductivity of the formed silicide structure.

In addition, Applicants have found that by limiting the time period of cobalt deposition, to 15 seconds or less, and by cooling the substrate during cobalt deposition, the desired deposition at low temperature is achieved, thereby avoiding formation of silicide during cobalt deposition and thereby avoiding junction leakage current.

However, the known practice has problems, in that a junction leakage current resulting from a deterioration in flatness occurs, on the interface between the silicon substrate and the cobalt layer. Note, in particular, pages 3 and 4 of Applicants' Substitute Specification.

Against this background, Applicants provide a process wherein the increase in junction leakage current is reduced. In particular, Applicants have found that by depositing the cobalt at such a low temperature that the silicide is not formed at the interface between the cobalt and silicon of the substrate at the time of deposition, with subsequent heat treatments taking place in order to form the silicide, it is possible to planarize the interface between the substrate and the finally-formed silicide layer composed mainly of cobalt disilicide, thereby preventing an increase in junction leakage current. Moreover, by forming the cobalt film at a low temperature and preventing generation of a reaction layer between silicon and cobalt at the interface between the substrate and the cobalt film <u>during film formation</u>, the subsequent silicide reaction can be allowed to proceed smoothly. See page 16, lines 10-13; and from page 21, line 9 through page 22, line 3, of Applicants' Substitute Specification.

Furthermore, since a well-formed cobalt disilicide layer is formed, by converting the cobalt monosilicide, a cobalt monosilicide layer or dicobalt silicide layer having a high resistance does not remain on the interface between the substrate and the cobalt disilicide layer, improving conductivity of the formed silicide structure.

In addition, Applicants have found that by limiting the time period of cobalt deposition, to 15 seconds or less, and by cooling the substrate during cobalt deposition, the desired deposition at low temperature is achieved, thereby avoiding formation of silicide during cobalt deposition and thereby avoiding junction leakage current.

Inoue discloses a method of forming a silicide layer on the surface of a gate electrode or the surface of a source or drain diffusion layer of an insulating gate type field effect transistor. The method includes forming a refractory metal silicide layer having a first phase structure, and then heat treating to change the refractory metal silicide layer having the first phase structure into a refractory metal silicide layer having a second phase structure. See column 4, lines 9-15. This patent discloses that the semiconductor substrate can be heated during performing a deposition operation of the refractory metal, in order to form the refractory metal silicide layer. See column 4, lines 16-20. This patent also discloses that in order to form a refractory metal silicide layer having the first phase structure, the refractory metal film may be deposited in a vacuum state; and, then, the semiconductor substrate may be heated in the vacuum state to change the refractory metal film into the refractory metal silicide layer having the first phase structure. See column 4, lines 26-31. Note also column 4, lines 32-43 and 53-65. Note also column 5, lines 1-8, reciting that the refractory metal is deposited in a state in which the semiconductor substrate is heated. See further column 6, lines 48-50 and 53-55, describing that in the sputtering at the described temperature of about 450°C, only a part of the surface of the diffusion layer 3 is silicided, with a Co_2Si film being formed in the silicidation. Note also column 9, lines 3-11 of this patent, stating that the Co_2Si film is formed at the same time as the sputtering film formation process is performed. Note also column 10, lines 56-66.

It is respectfully submitted that in Inoue a <u>silicide</u> <u>is formed</u> at the interface with the silicon, <u>as the cobalt is deposited</u>. Such technique would have neither taught nor would have suggested, and in fact would have <u>taught away from</u>, the presently claimed subject matter, including wherein in the step of depositing cobalt, the cobalt film is

deposited at a temperature lower than a temperature at which a reaction layer of silicon and cobalt is formed at the interface between the silicon substrate and the cobalt film, and advantages thereof as discussed in the foregoing; and/or the other features of the present invention, and advantages thereof.

It is respectfully submitted that the additional teachings of the secondary applied references, Murphy, et al. and Agnello, et al., would not have rectified the deficiencies of Inoue, such that the presently claimed invention as a whole would have been obvious to one of ordinary skill in the art.

Murphy, et al. discloses a technique for deposition of cobalt on a silicon substrate for the formation of cobalt silicide, wherein the cobalt is simultaneously deposited on the silicon substrate while the silicon substrate is being cleaned of native oxides on the surface of the silicon. See column 1, lines 6-13. As to the methods for depositing cobalt while simultaneously cleaning the native oxide, note column 2, line 46 through column 3, line 11. Note also column 4, lines 1-7.

Even assuming, arguendo, that the teachings of Murphy, et al. were properly combinable with the teachings of Inoue, such combined teachings would have neither disclosed nor would have suggested the presently claimed invention, including wherein the cobalt film is deposited at a temperature lower than a temperature at which a reaction layer of silicon and cobalt is formed at the interface between the silicon substrate the cobalt film, and advantages thereof, and/or other features of the present invention as discussed previously, and advantages thereof.

As applied by the Examiner, it is noted that Murphy, et al. discloses deposition of the cobalt film at a temperature as high as 300°C. It is respectfully submitted that such disclosure as in Murphy, of a wafer temperature during the cobalt deposition process,

would not have disclosed, nor would have suggested, deposition of cobalt without forming the reaction product at the interface, as in the present claims, and advantages thereof.

Agnello, et al. discloses a method for controlling interface roughness of a low resistivity electrical contact, wherein a cobalt or nickel alloy is employed in forming the electrical contact. The method described in Agnello, et al. includes forming a cobalt or nickel alloy over a silicon-containing substrate; optionally forming an oxygen barrier layer over the alloy layer; annealing the alloy layer at a temperature which is effective in forming a silicide layer; and removing the optional oxygen barrier layer and any remaining alloy layer. See column 2, lines 32-44. Note also column 4, lines 24-41, 57 and 58. See further column 5, lines 5-9.

Even assuming, arguendo, that the teachings of Agnello, et al. were properly combinable with the teachings of Inoue, or properly combinable with the combined teachings of Inoue and Murphy, et al., such teachings would have neither disclosed nor would have suggested the presently claimed invention, including deposition of cobalt at such a low temperature as to avoid a reaction product between the silicon and cobalt being formed at the interface therebetween, and advantages thereof, and/or the other features of the present invention and advantages thereof.

Specifically, it is emphasized that according to the present invention the cobalt is deposited at a relatively low temperature for not reacting cobalt film and silicon during the deposition,. notwithstanding that during the deposition heating of the substrate occurs. Reaction due to such heating of the substrate is avoided according to various features of the present invention, including cooling of the substrate, and/or especially wherein the deposition takes place in 15 seconds or less.

The contention by the Examiner in the first four lines on page 4 of the Office Action mailed January 27, 2005, that in Inoue the cobalt film is deposited at a temperature lower than a temperature at which a reaction layer of silicon and cobalt is formed on the interface between the silicon substrate and the cobalt film is respectfully traversed. Clearly, various embodiments of Inoue expressly disclose simultaneous deposition and reaction. Note, for example, disclosures in columns 4 and 5 of Inoue. It is respectfully submitted that there is no express disclosure in Inoue that the deposition is performed at a temperature lower than a temperature at which a reaction layer of silicon and cobalt is formed at the interface between the substrate and the cobalt film.

Furthermore, it is acknowledged that Murphy, et al. discloses cobalt deposition at a temperature of 20°C-300°C, and then annealing at 575°C. However, Murphy, et al. discloses cobalt film formation on a native oxide of the substrate, while applying a current flow to the silicon substrate. In contrast, according to the present invention the cobalt film is deposited on a bare silicon surface. It is respectfully submitted that the combined teachings of Murphy, et al. and of Inoue do not address the problem according to the present invention, arising in depositing cobalt on the bare silicon, nor the solution thereof wherein an uneven silicide is avoided so as to avoid junction leakage current.

The Examiner's attention is directed to the time period of cobalt deposition (that is, a period less than 15 seconds) as in various of the present claims. As described in the last paragraph on page 15 of Applicants' Specification, a temperature increase occurs during cobalt deposition, due to collision of cobalt molecules on the silicon surface. It is respectfully submitted that when cobalt molecules collide to the silicon wafer, the silicon wafer temperature rises causing a reaction between a cobalt film and

silicon film surface at the interface. By limiting the time of cobalt film deposition, reaction between the cobalt film and silicon film surface, due to the temperature increase caused by such collision, can be avoided. In this regard, note that temperature increase can occur even where the silicon wafer is located on a wafer chuck using a coolant, so that the cobalt film sputtering time as in the present claims achieves advantages in avoiding reaction between the cobalt and the silicon; and it is respectfully submitted that the cobalt deposition time, and advantages thereof, according to the present invention, would have neither been disclosed nor would have been suggested by the applied prior art.

In view of the foregoing comments and amendments, reconsideration and allowance of all claims presently in the application are respectfully requested.

Please charge any shortage in fees, in connection with the filing of this paper, including extension of time fees, or credit any overpayment of fees to Deposit Account No. 01-2135 (Case No. 501.343296X00).

Respectfully submitted,

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